Banco de México

Documentos de Investigación

Banco de México

Working Papers

N° 2016-14

Two Models of FX Market Interventions: The Cases of Brazil and Mexico

Martín Tobal
Banco de México

Renato Yslas
Banco de México

August 2016

Documento de Investigación
2016-14

Working Paper
2016-14

Two Models of FX Market Interventions: The Cases of Brazil and Mexico*

Martín Tobal†
Banco de México

Renato Yslas‡
Banco de México

Abstract: This paper empirically compares the implications of two distinct models of FX intervention, within the context of Inflation Targeting Regimes. For this purpose, it applies the VAR methodology developed by Kim (2003) to the cases of Mexico and Brazil. Our results can be summarized in three points. First, FX interventions have had a short-lived effect on the exchange rate in both economies. Second, the Brazilian model of FX intervention entails higher inflationary costs and this result cannot be entirely explained by differences in the level of pass-through. Third, each model is associated with a different interaction between exchange rate and interest rate setting (conventional monetary policies).
Keywords: Foreign exchange intervention; Exchange rate pass-through; Exchange rate regime; Monetary policy coordination.
JEL Classification: F31; E31; E52.

Resumen: Este documento compara empíricamente las implicaciones de dos modelos distintos de intervención cambiaria, en un contexto de regímenes de metas de inflación. Con este fin, el documento aplica la metodología VAR desarrollada por Kim (2003) a los casos de México y Brasil. Los resultados pueden resumirse fácilmente en tres puntos. Primero, las intervenciones cambiarias han tenido efectos de corta duración sobre el tipo de cambio en ambas economías. Segundo, el modelo de intervención cambiaria brasileño acarrea mayores costos de inflación e, interesantemente, este resultado no puede ser enteramente explicado por diferencias en el nivel de traspaso de tipo de cambio a precios. Tercero, cada uno de los modelos posee implicaciones distintas para la interacción entre política de tipo de cambio y tasa de interés (política monetaria convencional).
Palabras Clave: Intervención cambiaria; Traspaso del tipo de cambio; Régimen Cambiario; Coordinación de la política monetaria.

*The opinions expressed in this publication are those of the authors. They do not purport to reflect the opinions or views of Banco de México or its Board of Governors. We would like to thank for valuable comments João Barata Ribeiro Blanco Barroso, Fernando Tenjo, Daniel Chiquiar, Alberto Ortiz, Nicolás Magud, Fabricio Orrego, Julio Carrillo, Fernando Avalos, Santiago Garcia-Verdú, Victoria Nuguer and other participants of the Meeting of the Central Bank Joint Research of the Americas. Please address e-mail correspondence to: martin.tobal@banxico.org.mx

† Dirección General de Investigación Económica, Banco de México. Email: martin.tobal@banxico.org.mx.

‡ Dirección General de Estabilidad Financiera, Banco de México. Email: renato.yslas@banxico.org.mx.

1. Introduction

Historically, Latin America has seen a wide range of choices in terms of exchange rate and monetary policy regimes. Since the early 2000s a number of countries have opted for an Inflation Targeting Regime and devoted interest rate setting to meet the target. During this period, the goal of monetary policy has been almost exclusively to keep inflation under control. However, inflation targets and interest rate setting have come with varying degrees of exchange rate flexibility: Latin-American economies currently perform foreign exchange (FX) interventions under substantially different models. This paper investigates whether a country's choice of FX intervention model constrains their impact on the exchange rate, the country's inflation rate, and the nature of interaction between exchange rate and conventional monetary policies (interest rate setting). For this purpose, it uses the vector autoregression (VAR) model developed by Kim (2003) to compare the cases of Mexico and Brazil, two inflation targeting countries with distinct models of FX intervention.

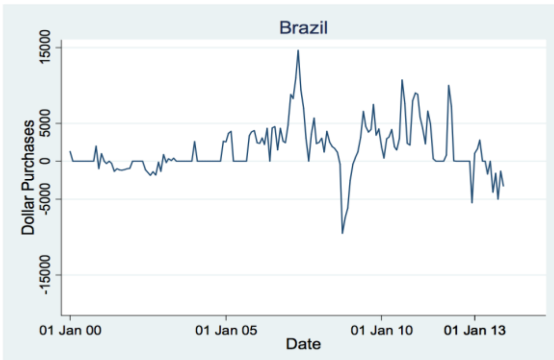
When asked about the exchange rate policies followed by Mexico and Brazil, most economists would probably classify them as *managed floating* policies (see Ilzetzki et al., 2008; Tobal, 2013 and IMF, 2015 for alternative exchange rate regime classifications).[1] However, as illustrated in Figures 1-2, using a single category for both countries would hide substantial differences across the two emerging markets. Figure 1 shows that the majority of Brazilian interventions have involved net dollar purchases and, importantly, they have been performed on a regular basis. On the other hand, the majority of Mexican interventions have involved net dollar sales and interventions have been more sporadic (mostly in the aftermath of the 2008-2009 financial crisis). Moreover, whereas Mexico has followed a pre-established rule, Brazil has primarily used discretionary interventions. In summary, although both

[1] The IMF *Annual Report on Exchange Arrangements and Exchange Restrictions* (2015) classifies both economies as inflation-targeters. As for their exchange rate regimes, there exists some variation. Ilzetzki et al. (2008) extend Reinhart and Rogoff´s classification of *de facto* exchange rate regimes for the period 2000-2010 and find that, over this period, both Brazil and Mexico had managed floating regimes. In a different paper, Tobal (2013) conducts a survey and assembles a unique database on foreign currency risk and exchange rate regimes. Using this information, he constructs an alternative classification based on self-report perceptions of regimes for seventeen Latin America and the Caribbean economies. According to this database, Brazil and Mexico had *pegged float* exchange rate regimes over the period 2000-2012. In an expanded classification that accounts for regulatory measures, Tobal (2013) reclassifies the Brazilian regime as *foreign exchange controls* over 2000 Q1 – 2005 Q2 to capture the existence of two regulated FX markets. Finally, in the IMF annual report (2015), the Brazilian and Mexican regimes are classified as floating and free floating, respectively.

Mexico and Brazil are inflation targeting countries, they represent two distinct models of FX interventions.

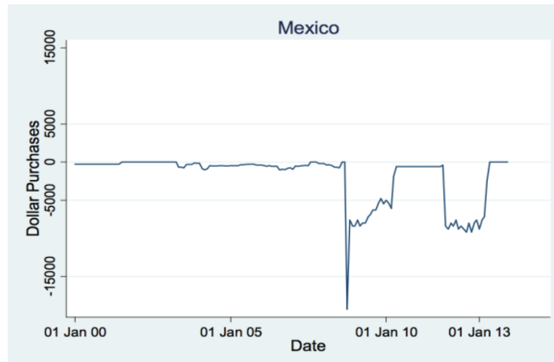
Foreign Exchange Intervention in Brazil and Mexico, 2000-2013
(Millions of US dollars)

FIGURE 1



Source: Banco Central do Brasil.
*Most interventions involved US dollar purchases.
**FX interventions include dollar purchases in the forward and spot markets, repurchases and foreign currency loans.

FIGURE 2



Source: Banco de México.
*Most interventions involved US dollar sales.
**FX interventions include dollar auctions, put options, mechanisms to slow the pace of reserve accumulation, and contingent dollar sales.

This paper compares empirically the two models of FX interventions by employing the VAR structure setup with short-run restrictions developed by Kim (2003). We adapt Kim's restrictions to the case of an emerging market and estimate his model with Mexican data on the one hand and with Brazilian data on the other hand.[2] Our choice of Kim's methodology is based on three facts. First, this methodology allows us to directly address the simultaneity bias present in studies on the effects of interventions on exchange rates. In particular, the model allows recovering a structural shock that is associated with FX interventions and is, at the same time, fully orthogonal to movements in the remaining variables or shocks. This feature is critical to avoid potential simultaneity bias arising from likely reactions of FX interventions to movements in the exchange rate. Second, Kim's SVAR methodology uses a single model to estimate the effects of FX interventions on a set of macroeconomic variables. By treating these variables as endogenous, the VAR method avoids potential bias stemming from the correlation of these macroeconomic outcomes (e.g. inflation) with FX interventions

[2] As noted below, Kim (2003) examines the interaction between FX interventions and interest rate setting for the case of the US.

and exchange rates. Third, the methodology accounts for interactions between exchange rate and conventional monetary measures. Hence, the present paper's estimates are not biased by the fact that countries frequently choose their policy mix by jointly deciding on the two policies.[3]

The first result of the paper shows that FX interventions have had a short-lived effect on the exchange rate in both Mexico and Brazil: a positive one-standard deviation shock in FX interventions is associated with depreciations of the Brazilian real and of the Mexican peso during one and two months, respectively. This result is consistent with findings in the literature that fully sterilized interventions have significant effects on the exchange rate in the short run (interventions are found to be sterilized in our model; see Tapia and Tokman, 2004; Rincón and Toro, 2010; Kamil, 2008; Echavarría et al., 2010; Echavarría et al., 2009; Kohlscheen and Andrade, 2013; Guimarães, 2004; and Section 2 for a thorough review).

The second result demonstrates that FX interventions have no inflation costs in Mexico but have costly inflation effects in Brazil. We investigate whether this result is driven by cross-country differences in exchange rate pass-through by studying the response of inflation to a shock in the exchange rate. Neither the timing nor the level of this response suggests that pass-through can entirely explain the higher inflation costs borne by Brazil. We then conclude that FX interventions are associated with higher inflation rates in Brazil, regardless of their effect on the exchange rate. Put differently, the FX interventions model adopted by Brazil seems to be inherently related to higher inflation rates (relative to the Mexican model).

The third result deals with the interaction between exchange rate and monetary policies. The paper studies the response of interest rate setting to a FX intervention shock and finds that the abovementioned interaction is of a different nature in each FX intervention model. Whereas the Central Bank of Mexico raises the interest rate immediately after the shock, the response of the Central Bank of Brazil appears only four months later. It is speculated that this result can be attributed to particular characteristics of the Brazilian model: the high

[3] For instance, by devaluing the exchange rate, dollar purchases may trigger inflationary pressures. To fight against these pressures, a central bank might raise the interest rate, partially offsetting the depreciation and, thus, the initial impact of the intervention on the exchange rate. That is, not accounting for the impact of monetary policy would tend to generate a downward bias on the estimated effect.

frequency with which the interventions are performed in this country may make it harder to change the interest rate in response to every inflationary pressure. In particular, the high frequency of the FX interventions may make it harder to accompany each of them with increases in the interest rate to offset its inflationary consequences. One implication is that, within the context of the Brazilian model, the relationship between conventional monetary policy and inflation rate becomes substantially noisier. At the same time, the later response of the interest rate to FX interventions in Brazil partially explains the second result, according to which these interventions entail higher inflationary costs.

As more thoroughly explained in Section 2, this paper makes two main contributions to studies that investigate the effectiveness of FX interventions in Mexico and Brazil. First, we base our study on a single model for conventional monetary policy, FX interventions, and exchange rate. From a methodological point of view, this contribution is relevant because FX interventions, monetary policy, and exchange rate interact with each other and not accounting for this interaction may generate sizable bias (Kim, 2003). Second, we compare the two countries and assess the implications of choosing different models of FX interventions.

The rest of the paper is organized as follows. Section 2 reviews the related literature and highlights the contributions of this paper to the literature. Section 3 explains the data, the methodology, and the identifying assumptions employed in the analysis. Section 4 discusses the empirical results and Section 5 examines the robustness of the results. Finally, section 6 concludes.

2. Related Literature

This paper relates to a set of studies investigating whether sterilized FX interventions are effective in influencing the level and volatility of the exchange rate. To investigate this issue, the literature has primarily employed single equation econometric models such as GARCH specifications, cross-country studies, and event study approaches. Overall, the literature is not conclusive on the effectiveness of FX interventions. Whereas some papers support the idea that FX interventions are effective solely in the short run, others find no evidence of significant effects (see Sarno and Taylor, 2001; Neely, 2005 and Menkhoff, 2013) for literature reviews).

For the particular case of Latin America, most studies show that FX interventions affect the level of the exchange rate in the short-run but are mixed about their effects on volatility (see Tapia and Tokman, 2004; Domaç and Mendoza, 2004; Kamil, 2008; Rincón and Toro, 2010; Adler and Tovar, 2011; Kohlscheen and Andrade, 2013; Broto, 2013; García-Verdú and Zerecero, 2014 and García-Verdú and Ramos-Francia, 2014). For Brazil, Stone et al. (2009) show that measures aimed at providing liquidity to the FX market affect the level and volatility of the Brazilian Real/US dollar rate.[4] Kohlscheen and Andrade (2013) use intraday data to demonstrate that a central bank's offer to buy currency swaps appreciates the exchange rate in Brazil.[5] For Mexico, Domaç and Mendoza (2004) find that dollar sales by the Central Bank appreciate the peso and have a negative impact on its volatility, while dollar purchases are found to be not statistically significant. In contrast, Broto (2013) employs a larger period (July 21, 1996–June 6, 2011) to show that both foreign currency purchases and sales are associated with lower exchange rate volatility. García-Verdú and Zerecero (2014) investigate the effects of dollar auctions without a minimum price on liquidity and orderly conditions. They show that, when these conditions are measured by bid-ask spreads, the aforementioned auctions improve liquidity and promote order in the FX market.[6] García-Verdú and Ramos-Francia (2014) take a lower frequency approach and use intraday data to investigate the consequences of FX interventions. Their result show that the effects of FX interventions on exchange rate risk-neutral densities are statistically little.[7]

In contrast with the studies on the effectiveness of FX interventions mentioned above, this paper does not employ a uni-equational econometric model for the exchange rate. Instead, we analyze this issue in a unifying framework for FX interventions, monetary policy, exchange rate, and inflation (among other variables). This is relevant because, as argued by Kim (2003), the two types of policies and the exchange rate interact with each other.

[4] Stone et al. (2009) study measures taken in the aftermath of the 2008-2009 financial crisis. They find that spot dollar sales and the announcements on futures market intervention appreciate the local currency.
[5] Note that by selling a currency swap to the Central Bank, the financial institution receives the equivalent of the exchange rate variation plus a local onshore US interest rate. This reduces its demand for foreign currency, consequently appreciating the exchange rate.
[6] The interventions considered by García-Verdú and Zerecero (2014) lasted five minutes. They show that this modality of intervention is associated with a lower bid-ask spread of the peso/dollar exchange rate.
[7] García-Verdú and Ramos-Francia (2014) use options data to estimate the exchange rate risk-neutral densities.

The paper also relates closely to a strand of literature that estimates a rich set of macroeconomic relationships and interactions between FX interventions and conventional monetary policy (see Kim, 2003; Guimarães, 2004; and Echavarría et al., 2009). To estimate these relationships, the literature employs structural VAR frameworks with short-run restrictions. For instance, Kim (2003) uses monthly data to show that net purchases of foreign currency substantially depreciate the exchange rate in the US. He also finds that even if these purchases are sterilized, they have significant effects on monetary variables in the medium run. Following Kim's framework (2003), Echavarría et al. (2009) jointly analyze the effects of FX intervention and conventional monetary policy on the exchange rate, interest rate, and other macroeconomic variables for Colombia. They show that foreign currency purchases devalue the nominal exchange rate over 1 month.[8]

In line with the VAR literature on FX interventions outlined above, this paper estimates the effects of interventions on a broader set of macroeconomic variables (including inflation and interest rates). In contrast with Kim (2003), Guimarães (2004), and Echavarría et al. (2009), we estimate these effects for two countries (Brazil and Mexico) that follow different models of intervention and analyze the implications of such differences in terms of inflation costs and interactions between FX intervention and conventional monetary policies.

Finally, the paper relates to research studying the existence of exchange rate pass-through. A number of papers have documented a notable reduction in the level of pass-through in both Mexico and Brazil since the early 2000s (e.g. Cortés, 2013; Capistrán *et al.*, 2012; Nogueira and León-Ledesma, 2009; Mihaljek and Klau, 2008; Nogueira, 2007; Belaisch, 2003). For instance, Nogueira (2007) shows the adoption of Inflation Targeting Regimes has reduced the level of pass-through in Mexico and Brazil (among other emerging economies). Notwithstanding its reduction, there still are references to exchange rate pass-through in both countries (see Barbosa-Filho, 2008, for the case of Brazil and Banco de Mexico´s Inflation Report from April-June 2011 for the case of Mexico). In this paper, we argue that this pass-through cannot entirely explain the inflation costs associated with FX interventions.

[8] Guimarães (2004) finds that yen purchases by the Central Bank of Japan appreciate the nominal exchange rate but have no significant effects on either money supply or interest rates.

3. Data and Methodology

3.1. Variable Definition and Structural VAR with Short Run Restrictions

We opt for restrictions linking endogenous variables in the short run for two reasons. First, the literature that uses long-run restrictions frequently assumes money neutrality to identify effects of monetary policy shocks (see Lastrapes and Selgin, 1995; Fackler and Mcmillin, 1998; and Mcmillin, 2001). Money neutrality is reasonable when linking real variables, but most of the variables in our VAR system are nominal. Second, models with short-run restrictions perform better in terms of accurately identifying FX market intervention and conventional monetary policy shocks (see Kim, 2003, and Faust and Leeper, 1997).[9]

Let y_t be the $7x1$ vector which includes first differences of the endogenous variables we consider. These variables and the corresponding data are summarized by the following list: the money market interest rate is used for the interest rate (i_t), the monetary base is employed for the monetary aggregate (m_t), the consumer price index is employed for consumer prices (cpi_t), industrial production is used as a proxy for output (ip_t), the local currency price of US dollars is used for exchange rate (e_t), a commodity price index is employed for commodity prices (pc_t) and, finally, net purchases of dollars are used for foreign exchange interventions (fei_t).[10,11] These endogenous variables and data are the same as those considered by Kim (2003) and very closely follow Echavarría et al.'s approach (2009). In contrast with those investigations, we take first differences to ensure that all the variables are stationary.[12]

---

[9] The correct identification of structural shocks rests on the correct estimation of the structural parameters. In this line, Faust and Leeper (1997) show that inferences from VARs based on long run assumptions might not be reliable because of data limitations. They argue that the long-run effects of structural shocks are not precisely estimated in small samples, and this inaccuracy transfers to impulse-response exercises. In other words, structural shocks might not be correctly identified when assuming long-run restrictions in finite samples.

[10] All variables are in log terms (multiplied by 100), with the exception of foreign exchange intervention and interest rates that are in percentage terms. We normalize foreign exchange intervention by the quadratic trend of the monetary base.

[11] For Brazil, foreign exchange interventions refer to interventions in the forward and spot markets, repo lines of credit, and foreign currency loans. For Mexico, foreign exchange interventions concern interventions through US dollar auctions, put options, contingent dollar sales mechanisms, and sales aimed at slowing the pace of reserve accumulation.

[12] According to the unit root tests for both Mexico and Brazil, all variables except foreign exchange interventions are integrated to an order of 1. Foreign exchange interventions are stationary in levels (see Appendix for further details).

The period under interest is defined to comprise the "Inflation Targeting" period and we use monthly data ("high-frequency information") to capture the impact of FX market interventions on the exchange rate. The sample period is thus defined as 2000M1-2013M12. The data come from different sources: the Banco Central do Brasil, the International Financial Statistics of the IMF, and the Banco de México.

The dynamics of the Brazilian and the Mexican economies are defined by the following structural model

$$A_0 y_t = A(L) y_{t-1} + \varepsilon_t \qquad (1)$$

where A_0 is a matrix of contemporaneous coefficients, $A(L)$ is a polynomial matrix in the lag operator L, and ε_t is a $7x1$ structural disturbance vector. The variance-covariance matrix of the structural disturbances is denoted by $var(\varepsilon_t) = \Sigma_\varepsilon$, where the diagonal elements are the variances of structural disturbances and the non-diagonal elements are assumed to equal zero (so that the structural disturbances are assumed to be mutually uncorrelated).

The reduced form of the structural model is obtained by multiplying the inverse of A_0 on both sides of (1), and is written as follows

$$y_t = B(L) y_{t-1} + u_t \qquad (2)$$

where $B(L)$ is $7x7$ polynomial matrix in the lag operator L and u_t is the $7x1$ vector of reduced form (estimated) residuals with $var(u_t) = \Sigma_u$. By estimating Equation (2), we will obtain estimates of $var(u_t) = \Sigma_u$ that will allow us to recover the structural parameters of the model defined in Equation (1).

In order to recover the structural parameters, it is important to note that the residuals of the structural and of the reduced form are related by $\varepsilon_t = A_0 u_t$. This implies $\Sigma_\varepsilon = A_0 \Sigma_u A'_0$, and yields a system of 49 equations. Thus, to recover the structural parameters, we need to impose at least 28 restrictions on A_0 and Σ_ε because 28 of the system's equations are independent and by plugging the sample estimates of $var(u_t) = \Sigma_u$, we are left with 56 unknowns.[13,14] As explained below, we will impose 35 parameter restrictions and over identify the system (see the next subsection for further details).

When imposing restrictions on A_0, the literature on structural VAR with short-run restrictions frequently employs the conventional normalization of the simultaneous equation literature. That is, it assumes that the 7 diagonal elements of A_0 are equal to 1. Also very frequently, the additional 21 restrictions arise from the assumption that A_0 is the lower triangular matrix (this assumption is referred to as the Cholesky decomposition in this literature).

An issue with the Cholesky decomposition is that it imposes a recursive structure on the contemporaneous relationships among the variables given by A_0, i.e. each variable is contemporaneously affected by those variables above it in the vector of endogenous variables y_t, but it does not contemporaneously affect them.[15] From a practical perspective, the problem with the recursive structure is that outcomes are frequently sensitive to changes in the variable ordering. In other words, each ordering might imply a different system of equations and thus yield different results.

3.2. Defining Contemporaneous Restrictions

In contrast with the common practice in the VAR literature that assumes that the 7 diagonal elements of A_0 are equal to 1, we follow Cushman and Zha's (1997) and Sims and Zha's (2006) approach by restricting the main diagonal elements in Σ_ε to equal 1.This approach has

[13] In general, there are $n(n+1)/2$ independent equations, where n equals the number of endogenous variables: all the $n(n-1)/1$ off-diagonal elements of $A_0\Sigma_u A_0'$ are equal to zero, and the n diagonal elements $A_0\Sigma_u A_0'$ are equal to the structural error variances. Furthermore, there are $n(n+1)$ structural parameters: the n^2 elements of A_0 plus the n diagonal elements of Σ_ε. Thus, once we assume the diagonal elements of A_0 or $\Sigma_\varepsilon$are equal to 1, we need to impose at least $n(n-1)/2$ additional restrictions. However, imposing those $n(n+1)/2$ restrictions is a necessary but not a sufficient condition to identify the structural system. For a necessary and sufficient condition see propositions 9.1 and/or 9.3 of Lütkepohl (2005).

[14] Imposing only 28 restrictions is a necessary but insufficient condition to identify the structural system.

[15] Note that when it is assumed to have a recursive structure, the assumption that the elements of its main diagonal equal 1 provides the additional restrictions to exactly identify the structural parameters.

the advantage of simplifying some formulas used in the inference and does not alter the economic substance of the system (Sims and Zha, 2006).[16]

With regard to the remaining 28 restrictions, we depart from the standard Cholesky decomposition by using the generalized method proposed by Blanchard and Watson (1986), Bernanke (1986), and Sims (1986). This approach allows for a broader set of contemporaneous relationships among the variables so that A_0 can have any structure, whether recursive or not. In particular, we impose the 28 short-run restrictions on A_0 listed in Table 1.[17] Each row in this table can be interpreted as a contemporaneous equation. For instance, the first row tells us how foreign exchange interventions react contemporaneously to movements in the remaining variables (the interest rate, etc.).

Table 1. A_0 Matrix and Contemporaneous Restrictions

	Δfei_t	Δi_t	Δm_t	Δcpi_t	Δip_t	Δe_t	Δpc_t
Δfei_t	g_{11}	0	0	0	0	g_{16}	0
Δi_t	g_{21}	g_{22}	g_{23}	0	0	0	0
Δm_t	0	g_{32}	g_{33}	g_{34}	g_{35}	0	0
Δcpi_t	0	0	0	g_{44}	g_{45}	g_{46}	0
Δip_t	0	0	0	0	g_{55}	0	0
Δe_t	g_{61}	g_{62}	g_{63}	g_{64}	g_{65}	g_{66}	g_{67}
Δpc_t	0	0	0	0	0	0	g_{77}

[16] Sims and Zha (2006) argue that this method "compels the reader to remain aware that the choice of 'left-hand-side' variable in the equations of models with the more usual normalization is purely a matter of notational convention, not economic substance" (p. 248).
[17] The over-identification is not rejected by the likelihood ratio test at any conventional level. In particular, the statistic equals 11.34 in the case of Brazil and 3.15 in the case of Mexico, with significance levels of 0.125 and 0.871 respectively (see Table A2 in the Appendix).

Note in the first row of Table 1 we assume that foreign exchange interventions react contemporaneously solely to the exchange rate. This assumption is consistent with the evidence provided by the leaning-against-the-wind literature and follows closely Kim (2003) and Echavarría et al. (2009)'s approach for the cases of the US and Colombia, respectively.[18]

The second row introduces the contemporaneous responses of Δi_t. The g_{21} and g_{23} parameters are left free to allow for the possibility that interventions are not fully sterilized and, interestingly, to capture their contemporaneous interaction with monetary policy. The contemporaneous response of Δi_t toward output and prices is assumed to be null (g_{24} and g_{25} = 0, which is based on Kim's argument that information on output and prices is not available within a month).[19] The contemporaneous response to the exchange rate is set to 0 because both Mexico and Brazil (formally) conduct monetary policy under inflation targets. Furthermore, in line with Echavarría et al. (2009) but in contrast with Kim (2003), g_{27} is assumed to equal 0. Kim (2003) assumes otherwise in order to solve the standard "price puzzle" that characterizes the US economy. The Appendix shows this puzzle appears only for Brazil and, to tackle this issue, Section 4 shows that allowing for g_{27} to be different from 0 does not alter any of our qualitative results.

The third row in Table 2 denotes the conventional money demand equation and the fourth and fifth rows (contemporaneously) determine price and output (see Sims and Zha (2006), Kim (1999), Kim and Roubini (2000), Kim (2003), and Echavarría et al. (2009) for other papers using the same money demand specification). The g_{41}, g_{42}, g_{43}, g_{47}, g_{51}, g_{52}, g_{53}, g_{54}, g_{56}, and g_{57} parameters are set to 0 because, as argued by Kim (2003), inertia, adjustment costs, and planning delays preclude firms from changing either prices or output immediately in response to monetary policy and financial signals. On the other hand, we take an agnostic approach with regard to contemporaneous "exchange rate pass-through." That is, we let prices contemporaneously respond to the exchange rate and thus leave the g_{46} parameter free. Section 4 shows that changing this assumption does not alter our qualitative results. See Section 2 for comments about pass-through in Cortés (2013), Capistrán *et al.*

[18] See, for instance, Adler and Tovar (2011) for a reference in this literature in which the main goal of interventions is to stabilize the exchange rate.

[19] This assumption has been widely used in the monetary literature of the business cycles. See Gordon and Leeper (1994); Kim and Roubini (2000) and Sims and Zha (2006) for references.

(2012), Nogueira and León-Ledesma (2009), Barbosa-Filho (2008), Mihaljek and Klau (2008), Nogueira (2007), and Belaisch (2003).

In the sixth row, we let the exchange rate respond contemporaneously to all of the variables. These assumptions are in line with Echavarría et al. (2009) but contrast with Kim (2003). Our and Echavarría et al. (2009)'s argument for the case of Colombia is that commodity prices are more relevant in determining the local currency in developing countries than in determining the US dollar.

Finally, in the seventh row, we assume that commodity prices are contemporaneously exogenous. This assumption arises from the fact that the economic conditions of Brazil and Mexico do not have such a strong impact on the IMF's price index of commodities as the economic conditions of the US. Brazil, for instance, is a large exporter of sugar, coffee, beef, poultry meat, soybeans, soybean meal, and iron ore. However, these products represent only 0.16 percent of non-fuel commodities, which in turn represent only an average of 0.37 percent for the commodity price index used in this paper. Along the same lines, Mexico produces only a small world share of its main export commodity: crude petroleum.[20]

4. Results

We add a constant, 4 lags, the US federal funds rate, and a dummy variable for 2008:10-2009:6 to the reduced-form in Equation (2) and estimate the resulting model.[21]

4.1. Impulse Responses to FX Intervention Shocks

Figures 3-8 and 11-18 report the responses of the endogenous variables to a one standard deviation shock in FX interventions. The figures that appear on the right refer to the impulse responses for Mexico and those on the left refer to Brazil. In order to facilitate the comparison we use the same scale in all figures.

[20] These data refer to the IMF's Commodity Price Index calculated between 2004 and 2013 (http://www.imf.org/external/np/res/commod/index.aspx).

[21] The dummy variable is included to account for the potential effect of the most recent financial crisis. The resulting reduced form of the model is written as follows: $y_t = a + B(L)y_{t-1} + Dx_t + d + u_t$ where a is a vector of constants, $B(L)$ is a polynomial matrix in the lag operator, D is the matrix of coefficients associated with the exogenous variables, x_t is the vector of exogenous variables, d is a dummy variable that equals 1 for 2008:10-2009:6, and u_t is the vector of reduced form residuals.

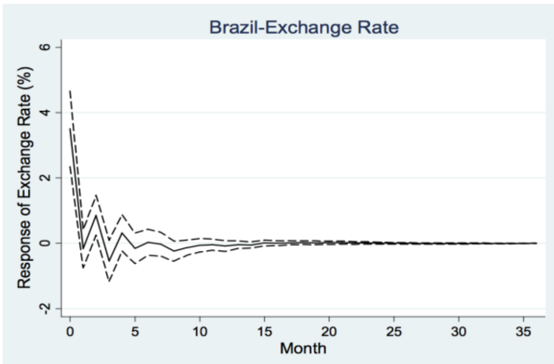
Figures 3-4 provide information on the effectiveness of FX market interventions. These figures show that net dollar purchases are associated with a significant impact on the exchange rate. In both Brazil and Mexico, the sign of the response is as expected since a positive shock in FX intervention generates a depreciation of the Brazilian real and of the peso (Figures 3 and 4, respectively). In both countries the effect is short-lived: whereas in Mexico this effect lasts two months, in Brazil the effect lasts only one month.

Figures 5-6 refer to the reaction of monetary bases to the positive FX intervention shock. Note that there are some fluctuations right after the shock in Brazil. However, the contemporaneous response of the monetary base is not significant in either Mexico or Brazil. This result, along with the evidence displayed in Figures 11-12, shows that FX interventions are not associated with an immediate expansion in the monetary conditions (i.e. an increase in the monetary base and a fall in the interest rate). Hence, we conclude that the interventions are fully sterilized in both Mexico and Brazil.

Putting together Figures 3-6 allows us to link our results with the empirical literature. In particular, the results presented in this paper are consistent with the findings that fully sterilized interventions have significant effects on the exchange rate in the short run (see Tapia and Tokman, 2004; Rincón and Toro, 2010; Kamil, 2008; Echavarría et al., 2010; Echavarría et al., 2009; Kohlscheen and Andrade, 2013; Guimarães, 2004; and Section 2 for a review of this literature). This consistency with the empirical literature provides external validity to the identification strategy we have pursued.

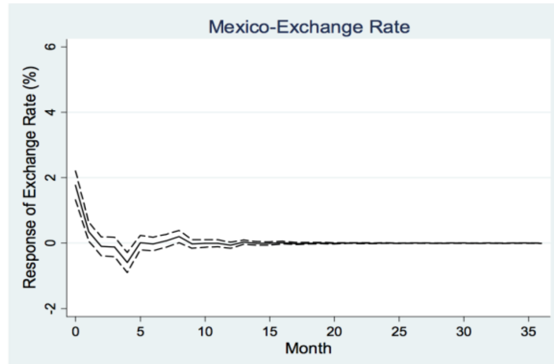
Impulse Responses to FX Intervention Shocks

FIGURE 3



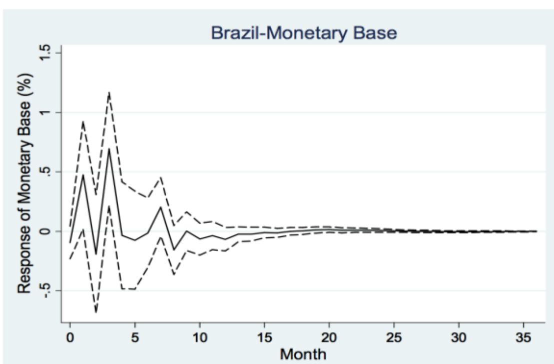
Sources: Banco Central do Brasil and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and goes up further 2 months later.
****Exchange rate is defined as national currency per US dollar.

FIGURE 4



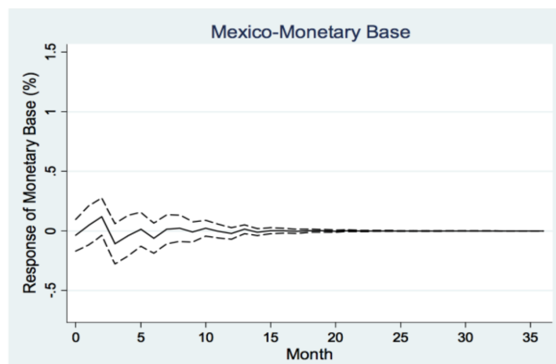
Sources: Banco de México and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and rises further one month later. Four months after the shock, it appreciates a bit.
****Exchange rate is defined as national currency per US dollar.

FIGURE 5



Sources: Banco Central do Brasil and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Monetary base fluctuates a bit in response: it increases 1 and 3 months after the shock.
****Monetary base is defined as the sum of the currency issued by the Central Bank and the banking reserves.

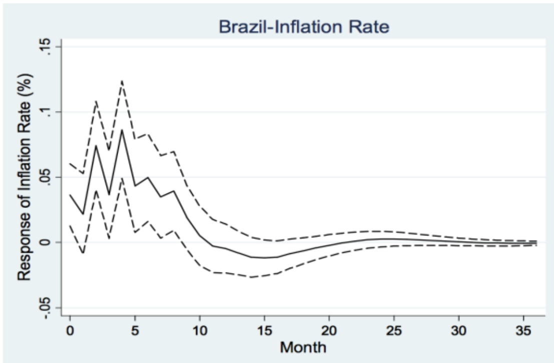
FIGURE 6



Sources: Banco de México and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Monetary base does not respond significantly to intervention shocks.
****Monetary base is defined as the sum of the currency issued by the Central Bank and the banking reserves.

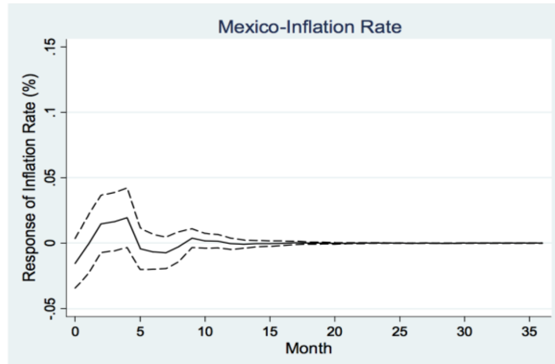
Impulse Responses to FX Intervention Shocks (continuation)

FIGURE 7



Sources: Banco Central do Brasil and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation rises on impact and then continues increasing from 2 to 8 months after the shock.
****Inflation is defined as the percentage change in the consumer price index.

FIGURE 8



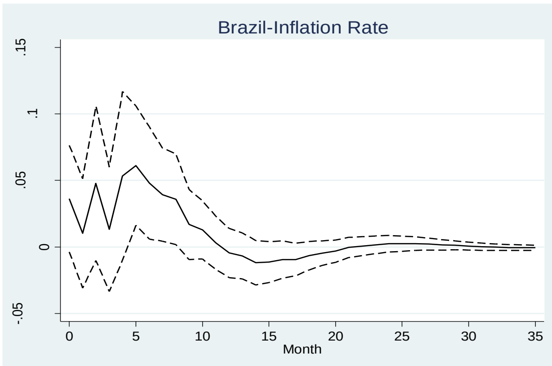
Sources: Banco de México and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation does not respond significantly to intervention shocks.
****Inflation is defined as the percentage change in the consumer price index.

Figures 7-8 provide information on the inflationary costs of FX interventions: they show the response of the inflation rate to a positive FX interventions shock in Brazil and Mexico, respectively. Note in these figures that the response of the inflation rate differs significantly across countries. In Brazil, a positive FX intervention shock is associated with significant increases in the inflation rate. This rate increases on impact and remains significantly high in Brazil until the eighth month (the effect is not statistically significant in the first month). The response of the inflation rate peaks at months 2 and 4 with significant increases of 0.074 and 0.086 percent, respectively. Note in Figure 8 that the shock, on the other hand, does not have a significant impact on inflation in Mexico at any period of time. Hence, whereas FX market interventions are costless in Mexico, they have inflation costs in Brazil.

The different responses of the inflation rate in Mexico and Brazil may refer to cross-country differences in pass-through. If the inflation rate responded more quickly and to a significantly greater extent in Brazil, the inflation costs borne by this country would be entirely explained by differences in the level and timing of pass-through. To further investigate this issue, we examine the responses of the inflation rate to a shock in the exchange rate and display the results in Figures 9-10.

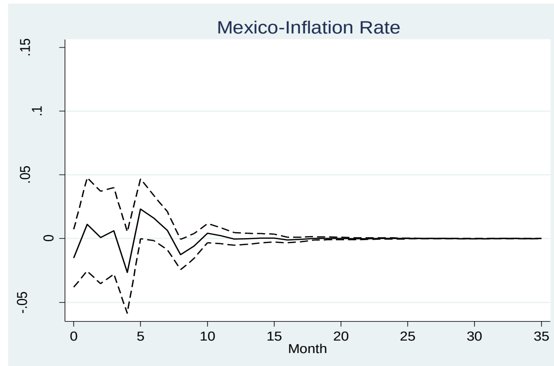
Response of Inflation Rate to Exchange Rate Shocks

FIGURE 9



Sources: Banco Central do Brasil and authors' calculations.
*The figure depicts the response to a positive exchange rate shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation goes up in response five months after the shock and keeps rising until the 8th month.
****Inflation is defined as the percentage change in the consumer price index.

FIGURE 10



Sources: Banco de México and authors' calculations.
*The figure depicts the response to a positive exchange rate shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation goes down in response eight months after the shock.
****Inflation is defined as the percentage change in the consumer price index.

Figure 10 shows that, in line with the evidence provided by Cortés (2013), Capistrán et al. (2012), and Nogueira (2007), the response of the inflation rate is statistically non-significant in Mexico (except for a tiny fall in the eighth month). Figure 9 shows that the response is significant in Brazil, but its timing and extent suggest that pass-through cannot entirely explain the results observed in Figure 7. The inflation increases on impact and peaks in the fourth month in response to the FX interventions shock (Figure 7), but it only begins to increase significantly in the fifth month in response to the shock in the exchange rate (Figure 9). Furthermore, the maximum response of the inflation rate to this shock equals 0.061 percentage points, which suggests a relatively small pass-through in Brazil. This result is consistent with the evidence presented in Section 2 , where the country has seen a significant reduction in the response of inflation to variations in the exchange rate (Nogueira and León-Ledesma, 2009; Mihaljek and Klau, 2008; Nogueira, 2007 and Belaisch, 2003).

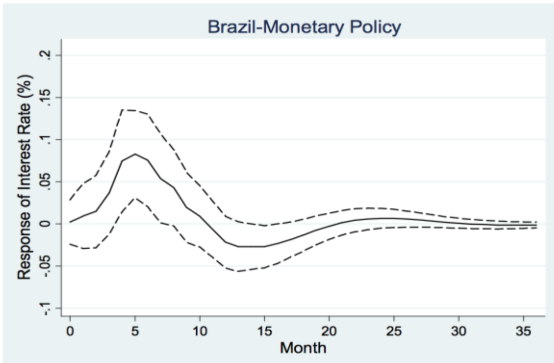
The fact that pass-through cannot entirely explain the different inflationary costs of FX interventions in Mexico and Brazil suggests the Brazilian model is inherently associated with higher inflation rates. To put it differently, FX interventions are associated with higher inflation in Brazil, regardless of their impact on the exchange rate. Thus, these interventions must cause an inflation increase through alternative mechanisms. A probable mechanism refers to the discretionary nature of the net dollar purchases performed by the central bank. Because one would expect expectations on inflation to be more unstable in a discretionary model, FX interventions may increase these expectations, thereby increasing inflation.

Before proceeding to the next subsection, we compare the interaction between exchange rate and conventional monetary policies across the two FX interventions models. Figures 11 and 12 display the responses of the interest rate to the FX interventions shock in Brazil and Mexico, respectively. Note in these figures that the nature of the interaction between the policies is of a different nature in each country. Whereas the interest rate increases immediately in response to the shock in Mexico, the Central Bank of Brazil raises this rate only four months after the shock. In other words, we observe a "late" response of interest rate setting in Brazil relative to Mexico. This result is not surprising given that the Brazilian model entails FX interventions that are performed on a more regular basis. Because interventions are relatively more frequent in Brazil than in Mexico, it may make it more difficult for Brazil to raise the interest rate during each intervention. Thus, we observe in Figure 12 a later response of the interest rate to the FX interventions shock.

The fact that interest rate setting responds later in Brazil may partially explain the results observed in Figures 7-8. Whatever the mechanism through which the Brazilian inflation increases is, the later response of monetary policy does not help reduce the different responses of the inflation rate to the FX interventions shock.

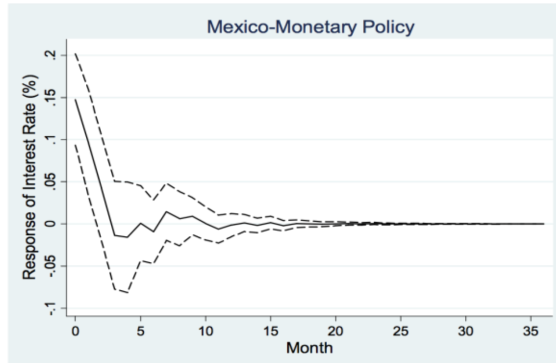
Impulse Responses to FX Intervention Shocks (continuation)

FIGURE 11



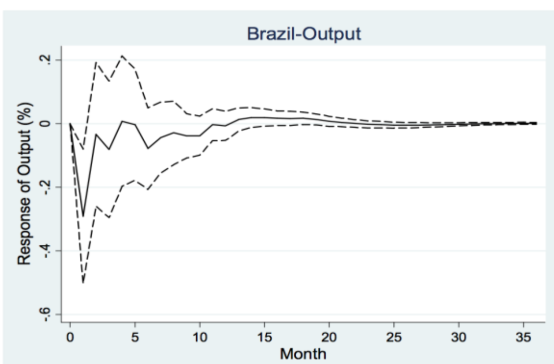
Sources: Banco Central do Brasil and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate increases four months after the shock and remains increasing until the 7th month.
****Money market interest rate is used for the interest rate.

FIGURE 12



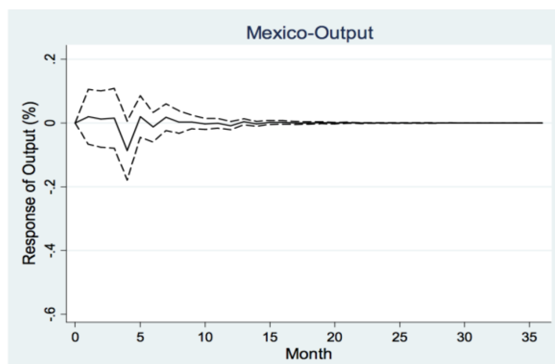
Sources: Banco de México and authors' calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate goes up on impact and increases again the next month.
****Money market interest rate is used for the interest rate.

FIGURE 13



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Output falls in response 1 month after the shock.
****Industrial production is used as a proxy for output.

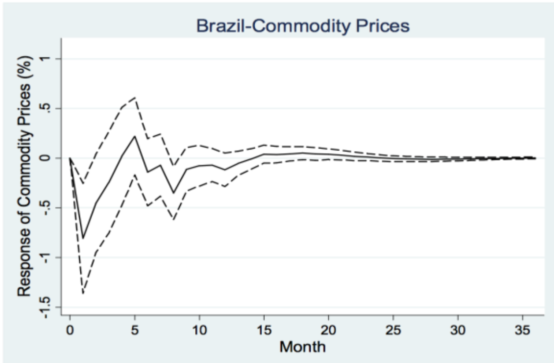
FIGURE 14



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Output does not significantly respond to intervention shocks.
****Industrial production is used as a proxy for output.

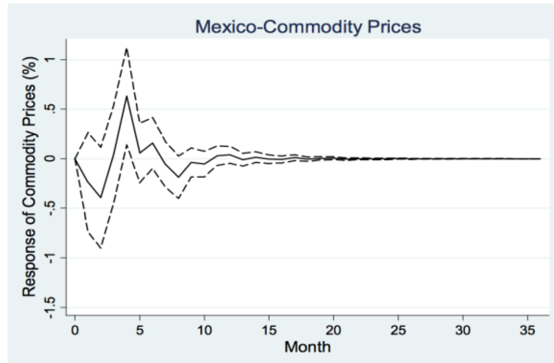
Impulse Responses to FX Intervention Shocks (continuation)

FIGURE 15



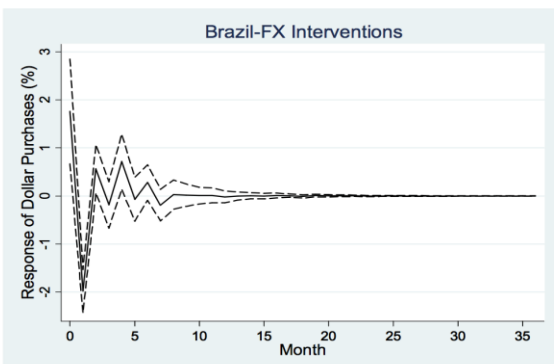
Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Commodity prices fall in response 1 month after the shock, and goes down further 7 months later.
***IMF´s commodity price index is used for commodity prices.

FIGURE 16



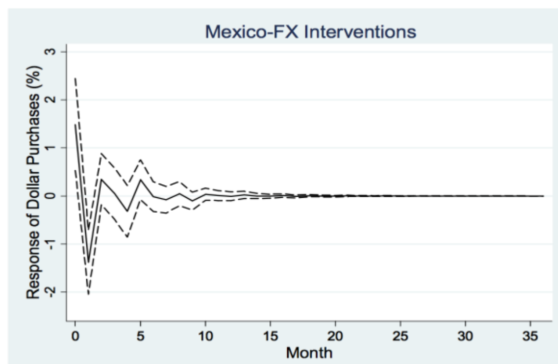
Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Commodity prices go up in response 4 months after the shock.
***IMF´s commodity price index is used for commodity prices.

FIGURE 17



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Dollar purchases increase on impact and then fluctuate in the next four months.

FIGURE 18



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Dollar purchases increase on impact and reduce in the next month.

4.2. Variance Decomposition

Tables 2-3 display the forecast error variance decomposition of inflation for Brazil and Mexico, respectively. Each column in these tables refers to one of the seven shocks and shows the proportion of the variance in the inflation rate that is explained by the corresponding shock at a given horizon. Let us first focus on how the proportions associated with FX interventions and exchange rate shocks vary over time. The first column in Table 2 shows that in Brazil the proportion of the variance in the inflation rate explained by FX interventions shocks increases over time and stabilizes by the 24th month. The sixth column shows that a similar conclusion can be drawn with regard to exchange rate shocks. This behavior is also observed for Mexico in Table 3, with the only difference being that the proportions stabilize earlier in this country—by the twelfth month.

Table 2. Forecast Error Variance Decomposition of Inflation in Brazil

Months	Shocks						
	FX Interventions	Interest Rate	Money Demand	Consumer Prices	Output	Exchange Rate	Commodity Prices
1 month	0.037 (0.028)*	0.000 (0.000)*	0.000 (0.000)*	0.936 (0.054)*	0.004 (0.010)*	0.021 (0.027)*	0.002 (0.003)*
6 month	0.175 (0.075)*	0.030 (0.035)*	0.036 (0.037)*	0.559 (0.083)*	0.061 (0.044)*	0.058 (0.063)*	0.081 (0.045)*
12 month	0.206 (0.089)*	0.032 (0.033)*	0.040 (0.038)*	0.506 (0.088)*	0.059 (0.042)*	0.079 (0.075)*	0.078 (0.041)*
24 month	0.208 (0.090)*	0.034 (0.035)*	0.042 (0.040)*	0.499 (0.090)*	0.060 (0.042)*	0.081 (0.077)*	0.078 (0.042)*
36 month	0.208 (0.090)*	0.034 (0.035)*	0.042 (0.040)*	0.499 (0.090)*	0.060 (0.042)*	0.081 (0.077)*	0.078 (0.042)*

Sources: Banco Central do Brasil and authors´ calculations.
*Standard error in parentheses.

Table 3. Forecast Error Variance Decomposition of Inflation in Mexico

Months	Shocks						
	FX Interventions	Interest Rate	Money Demand	Consumer Prices	Output	Exchange Rate	Commodity Prices
1 month	0.008	0.002	0.000	0.959	0.027	0.003	0.000
	(0.012)*	(0.004)*	(0.000)*	(0.032)*	(0.025)*	(0.005)*	(0.001)*
6 month	0.029	0.023	0.074	0.810	0.033	0.016	0.015
	(0.026)*	(0.017)*	(0.039)*	(0.054)*	(0.024)*	(0.012)*	(0.019)*
12 month	0.032	0.025	0.074	0.799	0.033	0.021	0.017
	(0.029)*	(0.017)*	(0.038)*	(0.056)*	(0.024)*	(0.014)*	(0.019)*
24 month	0.032	0.025	0.074	0.799	0.033	0.021	0.017
	(0.029)*	(0.017)*	(0.038)*	(0.056)*	(0.024)*	(0.014)*	(0.020)*
36 month	0.032	0.025	0.074	0.799	0.033	0.021	0.017
	(0.029)*	(0.017)*	(0.038)*	(0.056)*	(0.024)*	(0.014)*	(0.020)*

Sources: Banco de México and authors´ calculations.
*Standard error in parentheses.

There are substantial differences, however, in the magnitude of the proportions across countries. FX interventions shocks explain 3.7 percent of the variance in the Brazilian inflation rate one month after the shock and 20.8 percent from two years onwards. These figures are substantially higher than the corresponding 0.8 and 3.2 percent observed in the first column of Table 3 for the case of Mexico. Although the forecast error variance decomposition analysis does not aim at establishing a causal relationship between exchange rate policy and inflation rate, it supports the result that FX interventions are more costly in Brazil than in Mexico (as mentioned in the previous subsection).

As for the proportions explained by shocks in the exchange rate, the figures are notably small in both countries. For Brazil, these proportions equal 2.1 and 8.1 percent at 1 and at 24 months, respectively. For Mexico, the proportions equal 0.3 and 2.1. These numbers support the idea that the level of pass-through is small in both economies.

Certainly, the level of pass-through is greater for Brazil than it is for Mexico in absolute terms. However, the proportion explained by exchange rate shocks is smaller relative to the corresponding proportion associated with FX interventions shocks for the case of Brazil. For instance, the difference between the figures that appear in the sixth and first columns equals 1.6 and 12.7 percent at 1 and 24 months for Brazil and 0.5 and 1.1 percent for Mexico. This result supports the result that differences in the level of pass-through cannot entirely explain the fact that FX interventions have higher inflationary costs in Brazil than in Mexico.

5. Robustness

This subsection examines the robustness of our results by changing identifying restrictions. We focus on two cases: the contemporaneous response of the interest rate to commodity prices and the response of consumer prices to the exchange rate (concerning the g_{27} and g_{46} parameters, respectively). Three reasons motivate this analysis. First, by imposing these restrictions, our model departs from either Kim's (2003) setup and/or Echavarría et al.'s (2009) approach. Second, the restriction on g_{27} is connected to the empirical finding that some economies present a "price puzzle," i.e. prices do not always respond in the expected direction to conventional monetary policy. This finding is relevant to our study because the original set of contemporaneous restrictions we have imposed generates a "price puzzle" for the case of Brazil.[22] Third, the restriction on g_{46} is connected to contemporaneous pass-through and, therefore, is at the core of our main results.

[22] The result that inflation increases in response to a monetary policy tightening in Brazil comes from at least two main sources. First, this response might be part of a more general problem identified in the SVAR literature, according to which the forward-looking nature of central banks may not be fully captured: given that that central banks react in advance to inflationary pressures, SVAR models that do not include information about prospective pressures may be unable to identify "true" monetary policy shocks. To solve for this so-called "price puzzle", some authors include commodity prices in the VAR estimations under the argument that these prices reflect inflationary pressures that are not incorporated in other variables (Sims, 1992; Christiano et al., 1999; Kim, 1999, 2003 and Sims and Zha, 2006). The present paper shows the result of this exercise in the appendix.

The review of the two identifying restrictions yields the three alternative models that are described by the following conditions: $g_{27} \neq 0$; $g_{46} = 0$; and $g_{46} = 0$ and $g_{27} \neq 0$. For the sake of brevity, we present solely the response of Δcpi_t to a shock in Δi_t for the first case and the responses of Δcpi_t and Δi_t to the FX interventions shock for the three cases. Presenting these responses allows us to show that the "price puzzle" disappears when $g_{27} \neq 0$ and to examine the robustness of the model to changes in the two identifying restrictions. Figures 19-38 show the responses for the three alternative models.

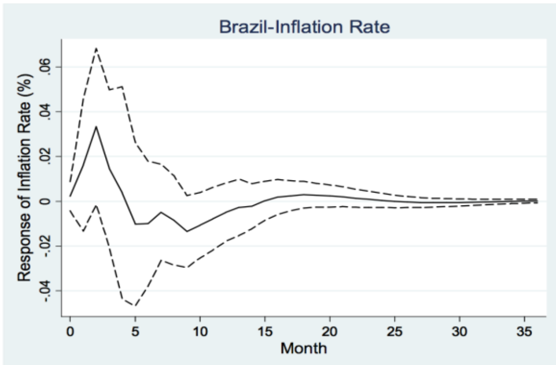
Note in Figure 19 that when $g_{27} \neq 0$, the "price puzzle" disappears in Brazil; thus a rise in the interest rate is not associated with an increase in the inflation rate.[23] In both this model and in the remaining two setups, the consideration of alternative identifying restrictions modifies neither the qualitative results nor the significance of the responses. In particular, in the three alternatives we observe that (i) FX interventions are effective in both countries and their effects on the exchange rate are short-lived; (ii) the inflation rises in response to the shock in Brazil but does not respond significantly in Mexico; and (iii) the central bank increases the interest rate immediately after the shock in Mexico but it does not do that in Brazil.

Second, the unexpected response of inflation rates to monetary policy may also be due to idiosyncratic features of the Brazilian economy. As discussed below, the fact that Brazil intervenes frequently in the FX market is likely to introduce noise in the relationship between the interest rate and inflation. This fact may make it more difficult to raise the interest rate during each intervention to offset inflationary pressures.

[23] However, leaving g_{27} free does not solve completely the puzzle; we do not observe a fall in the inflation rate in response to a contractionary monetary policy shock as would be predicted by standard economic theory.

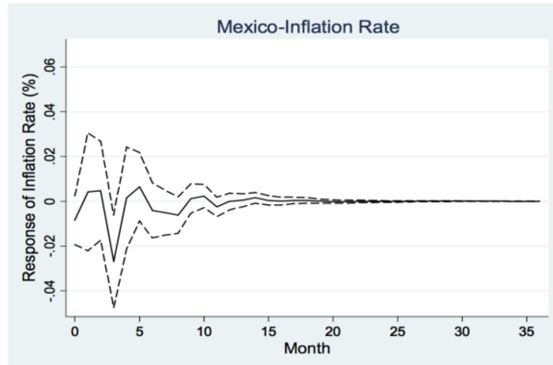
Response of Inflation Rate to Interest Rate Shocks under $g_{27} \neq 0$

FIGURE 19



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive interest rate shock in t=0.
**The dashed lines are 90% confidence bounds.
***We do not find evidence of the *price puzzle*; i.e. inflation rate does not rise significantly in response to interest rate shocks.
****Inflation is defined as the percentage change in the consumer price index.

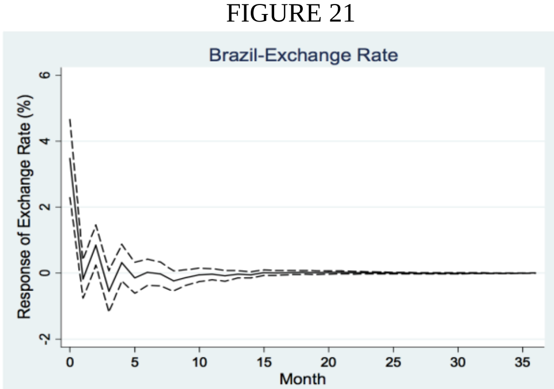
FIGURE 20



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive interest rate shock in t=0.
**The dashed lines are 90% confidence bounds.
***Inflation rate goes down in response 3 months after the shock
****Inflation is defined as the percentage change in the consumer price index.

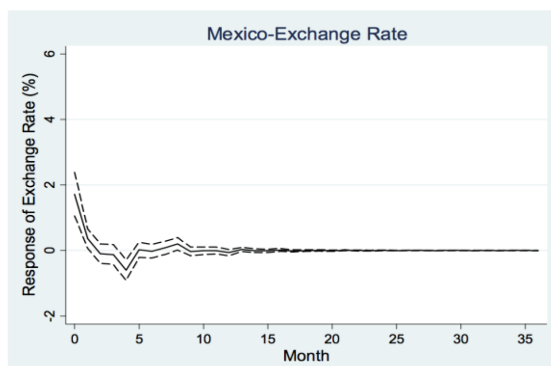
Impulse Responses to Foreign Exchange Interventions Shocks under Alternative Identifying Assumptions: $g_{27} \neq 0$

FIGURE 21



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and rises further 2 months later.
****Exchange rate is defined as national currency per US dollar.

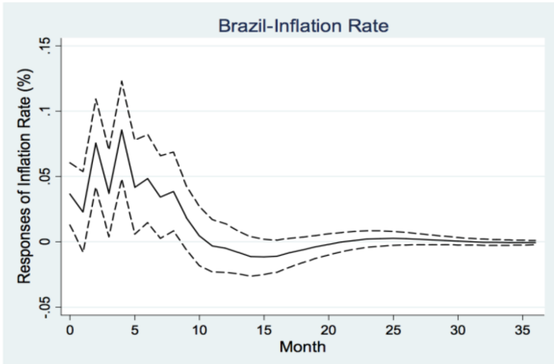
FIGURE 22



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX intervention shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and goes up further one month later. Four months after the shock, it appreciates a bit.
****Exchange rate is defined as national currency per US dollar.

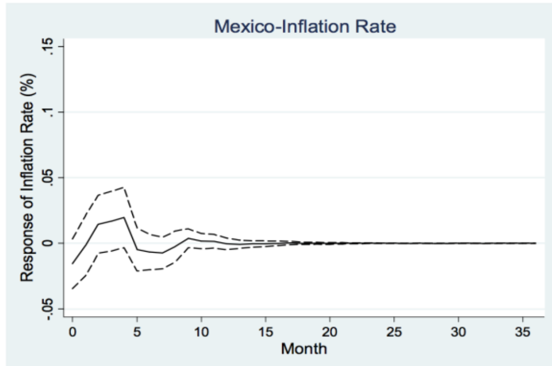
Impulse Responses to Foreign Exchange Interventions Shocks under Alternative Identifying Assumptions: $g_{27} \neq 0$ (continuation)

FIGURE 23



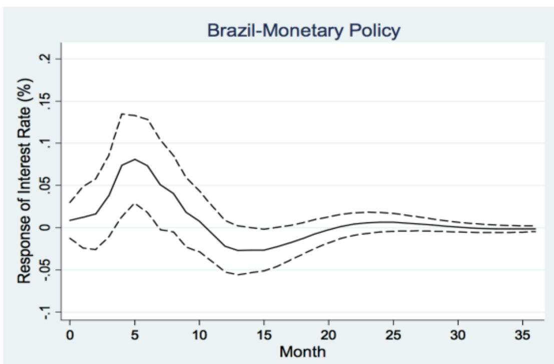
Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation goes up on impact and then continues increasing from 2 to 8 months after the shock.
****Inflation is defined as the percentage change in the consumer price index.

FIGURE 24



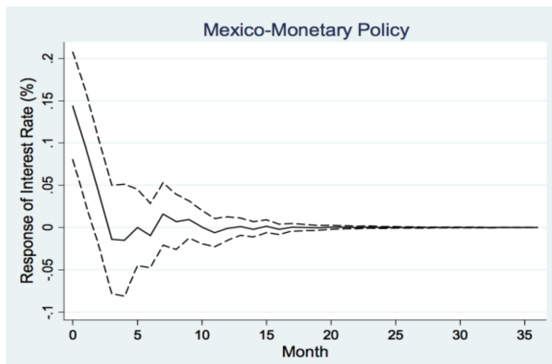
Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation does not respond significantly to intervention shocks.
****Inflation is defined as the percentage change in the consumer price index.

FIGURE 25



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate increases four months after the shock and remains increasing until the 6th month.
****Money market interest rate is used for the interest rate.

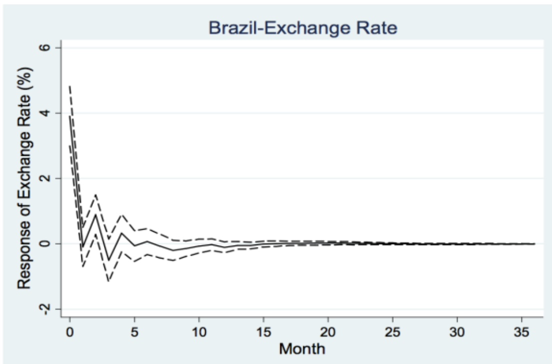
FIGURE 26



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate goes up on impact and increases again the next month.
****Money market interest rate is used for the interest rate.

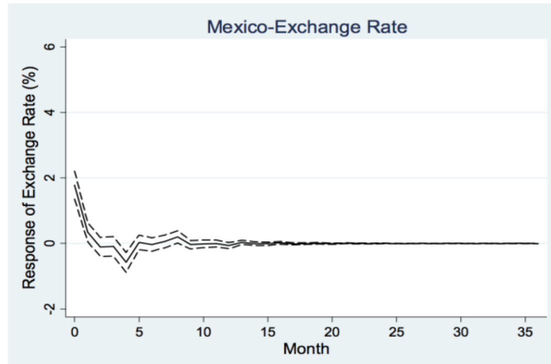
Impulse Responses to Foreign Exchange Interventions Shocks under Alternative Identifying Assumptions: $g_{46} = 0$

FIGURE 27



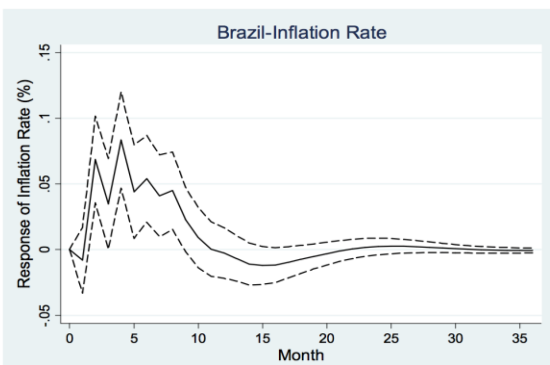
Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and rises further 2 months later.
****Exchange rate is defined as national currency per US dollar.

FIGURE 28



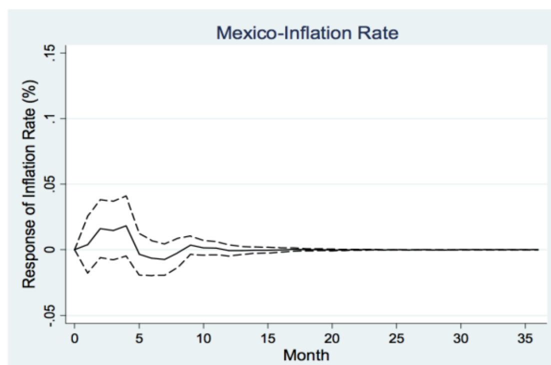
Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and goes up further one month later. Four months after the shock, it appreciates a bit.
****Exchange rate is defined as national currency per US dollar.

FIGURE 29



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation goes up 2 months after the shock and keeps rising until the 8th month.
****Inflation is defined as the percentage change in the consumer price index.

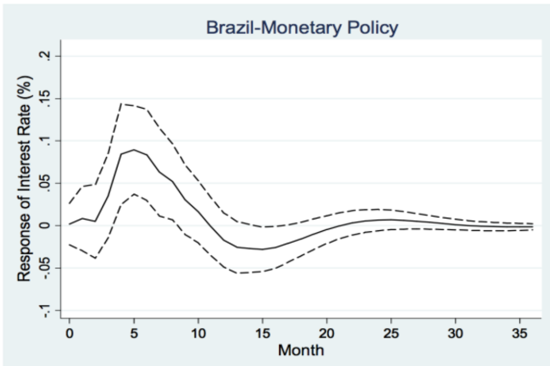
FIGURE 30



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation does not respond significantly to interventions shocks.
****Inflation is defined as the percentage change in the consumer price index.

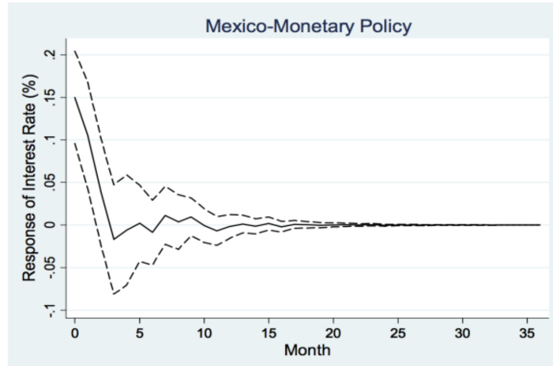
Impulse Responses to Foreign Exchange Interventions Shocks under Alternative Identifying Assumptions: $g_{46} = 0$ (continuation)

FIGURE 31



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate increases four months after the shock and remains increasing until the 8th month.
****Money market interest rate is used for the interest rate.

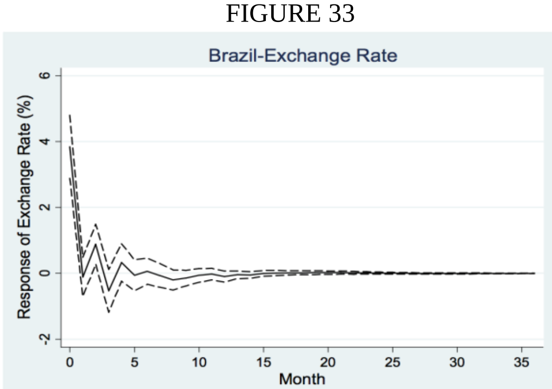
FIGURE 32



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate goes up on impact and increases again the next month.
****Money market interest rate is used for the interest rate.

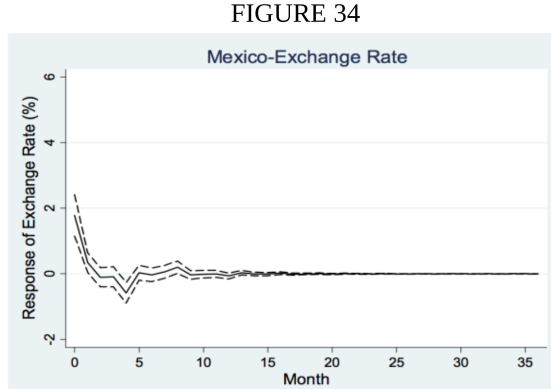
Impulse Responses to Foreign Exchange Interventions Shocks under Alternative Identifying Assumptions: $g_{46} = 0$ and $g_{27} \neq 0$

FIGURE 33



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and rises further 2 months later.
****Exchange rate is defined as national currency per US dollar.

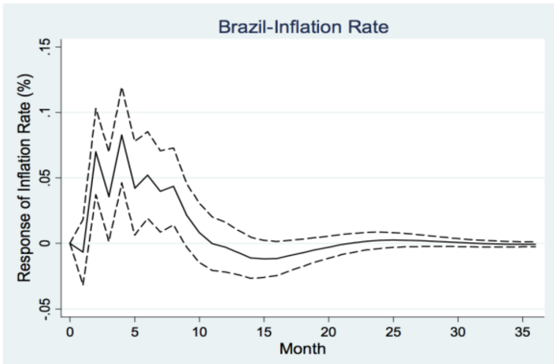
FIGURE 34



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Exchange rate depreciates on impact and goes up further one month later.
****Exchange rate is defined as national currency per US dollar.

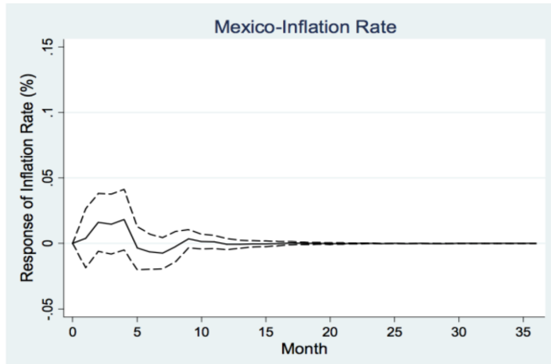
Impulse Responses to Foreign Exchange Interventions Shocks under Alternative Identifying Assumptions: $g_{46} = 0$ and $g_{27} \neq 0$ (continuation)

FIGURE 35



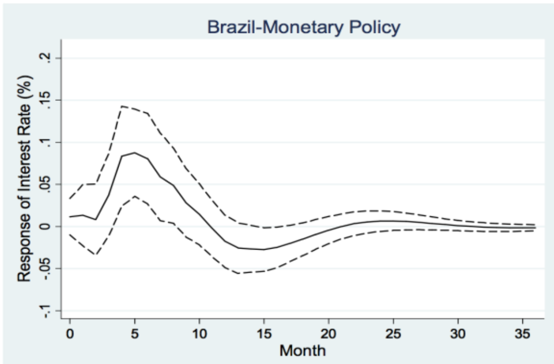
Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation goes up 2 months after the shock and keeps rising until the 8th month.
****Inflation is defined as the percentage change in the consumer price index.

FIGURE 36



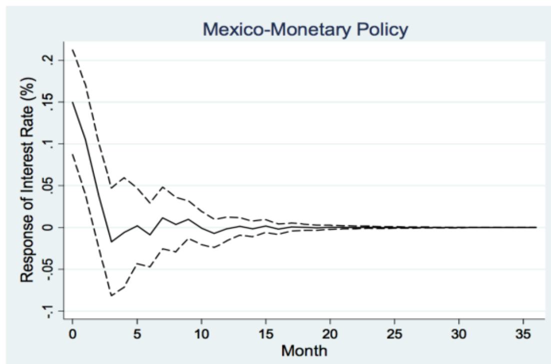
Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Inflation does not respond significantly to interventions shocks.
****Inflation is defined as the percentage change in the consumer price index.

FIGURE 37



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate increases four months after the shock and remains increasing until the 8th month.
****Money market interest rate is used for the interest rate.

FIGURE 38



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive FX interventions shock at t=0.
**The dashed lines are 90% confidence bounds.
***Interest rate goes up on impact and increases again the next month.
****Money market interest rate is used for the interest rate.

6. Conclusions

This paper has provided evidence of three major results. First, FX interventions have been successful in having a short-run impact on the exchange rate in both Mexico and Brazil. This outcome is consistent with an existing literature that investigates the effects of FX interventions in Latin-America. Second, we have found that different FX intervention models generates differential inflationary costs, with the costs being higher in a model that involves interventions that are discretionary and of a higher-frequency. Third, the evidence suggests that this second result cannot not be entirely driven by cross-country differences in the level of exchange rate pass-through.

Indeed, the higher inflationary costs associated with the Brazilian model seem to be at least partially associated with the implicit interaction between FX interventions and interest rate setting (conventional monetary policy). In particular, adopting a model that entails interventions on a regular basis seems to make it more difficult to compensate them with increases in the interest rate. That is, this intervention model makes the relationship between interest rates and inflation significantly noisier.

7. References

Adler, G. and C. E. Tovar (2011). Foreign Exchange Intervention: A Shield against Appreciation Winds? *IMF Working Paper*, WP/11/165, International Monetary Fund.

Barbosa-Filho, N. (2008). Inflation Targeting in Brazil: 1999-2006. *International Review of Applied Economics,* 22(2), pp. 187-200.

Belaisch, A. (2003). Exchange Rate Pass-through in Brazil. *IMF Working Paper*, WP/3/141, International Monetary Fund.

Bernanke, B. S. (1986). Alternative Explanations of the Money-Income Correlation. *Carnegie-Rochester Conference Series on Public Policy,* 25(1), pp. 49-99.

Blanchard, O. J. and M. W. Watson (1986). Are Business Cycles all Alike? in Robert J. Gordon (ed.), *The American Business Cycle: Continuity and Change*, University of Chicago Press, pp. 123-180.

Broto, C. (2013). The Effectiveness of Forex Interventions in Four Latin American Countries. *Emerging Markets Review,* 17, pp. 224-240.

Capistrán, C., R. Ibarra and M. Ramos-Francia (2012). El Traspaso de Movimientos del Tipo de Cambio a los Precios. Un Análisis para la Economía Mexicana. *El Trimestre Económico,* 79 (4), pp. 813-838.

Christiano, L. J., M. Eichenbaum and C. L. Evans (1999). Monetary Policy Shocks: What Have We Learned and to What End? *Handbook of macroeconomics*, 1, 65-148.

Cortés Espada, J. F. (2013). Estimación del Traspaso del Tipo de Cambio a los Precios en México. *Monetaria,* 35(2), pp. 311-344.

Cushman, D. O. and T. Zha (1997). Identifying Monetary Policy in a Small Open Economy under Flexible Exchange Rates. *Journal of Monetary Economics*, 39(3), pp. 433-448.

Domaç, I. and A. Mendoza (2004). Is there Room for Foreign Exchange Interventions under an Inflation Targeting Framework? Evidence from Mexico and Turkey. *World Bank Policy Research Working Paper,* 3288, World Bank.

Echavarría, J. J., E. López and M. Misas (2009). Intervenciones Cambiarias y Política Monetaria en Colombia. Un Análisis de VAR Estructural. *Borradores de Economía,* 580, Banco de la República.

Echavarría, J. J., D. Vásquez, and M. Villamizar (2010). Impacto de las Intervenciones Cambiarias sobre el Nivel y la Volatilidad de la Tasa de Cambio en Colombia. *Ensayos Sobre Política Económica,* 28(62), pp. 12-69.

Fackler, J. S. and W. D. McMillin (1998). Historical Decomposition of Aggregate Demand and Supply Shocks in a Small Macro Model. *Southern Economic Journal,* 64(3), pp. 648-664.

Faust, J. and E. M. Leeper (1997). When Do Long-Run Identifying Restrictions Give Reliable Results? *Journal of Business and Economic Statistics,* 15(3), pp. 345-353.

García-Verdú, S. and M. Ramos-Francia (2014). Interventions and Expected Exchange Rates in Emerging Market Economies. *The Quarterly Journal of Finance,* 4(01), 1450002.

García-Verdú, S. and M. Zerecero (2014). On Central Bank Interventions in the Mexican Peso/Dollar Foreign Exchange Market. *Banco de México Working Papers*, 2014-19, Banco de México.

Gordon, D. B. and E. M. Leeper (1994). The Dynamic Impacts of Monetary Policy: An Exercise in Tentative Identification. *Journal of Political Economy,* 102(6), pp. 1228-1247.

Guimarães, R. F. (2004). Foreign Exchange Intervention and Monetary Policy in Japan: Evidence from Identified VARs. *Money, Macro, and Finance (MMF) Research Group Conference 2004-8*, Cass Business School, London.

International Monetary Fund (Ed.) (2015), *Annual Report on Exchange Arrangements and Exchange Restrictions, 2005*. International Monetary Fund.

Ilzetzki, E., C. Reinhart and K. Rogoff (2008). Exchange Rate Arrangements entering the 21st Century: Which Anchor will Hold? *University of Maryland and Harvard University.*

Kamil, H. (2008). Is Central Bank Intervention Effective under Inflation Targeting Regimes? The Case of Colombia. *IMF Working Paper*s, WP/08/88, International Monetary Fund.

Kim, S. (1999). Do Monetary Policy Shocks Matter in the G-7 Countries? Using Common Identifying Assumptions about Monetary Policy across Countries. *Journal of International Economics,* 48(2), pp. 387-412.

Kim, S. (2003). Monetary Policy, Foreign Exchange Intervention, and the Exchange Rate in a Unifying Framework. *Journal of International Economics,* 60(2), pp. 355-386.

Kim, S. and N. Roubini (2000). Exchange Rate Anomalies in the Industrial Countries: A Solution with a Structural VAR Approach. *Journal of Monetary Economics*, 45(3), pp. 561-586.

Kohlscheen, E. and S. C. Andrade (2013). Official Interventions through Derivatives: Affecting the Demand for Foreign Exchange. *Banco Central do Brasil Working Papers*, 317, Banco Central do Brasil.

Lastrapes, W. D. and G. Selgin (1995). The Liquidity Effect: Identifying Short-Run Interest Rate Dynamics using Long-Run Restrictions. *Journal of Macroeconomics,* 17(3), pp. 387-404.

Lütkepohl, H. (2005), *New Introduction to Multiple Time Series Analysis,* Springer-Verlag, Germany, 764 pages.

McMillin, W. D. (2001). The Effects of Monetary Policy Shocks: Comparing Contemporaneous versus Long-Run Identifying Restrictions. *Southern Economic Journal,* 67(3), pp. 618-636.

Menkhoff, L. (2013). Foreign Exchange Intervention in Emerging Markets: A Survey of Empirical Studies. *World Economy,* 36(9), pp. 1187-1208.

Mihaljek, D. and M. Klau (2008). Exchange Rate Pass-through in Emerging Market Economies: What Has Changed and Why? in Bank for International Settlements (ed.), *Transmission Mechanisms for Monetary Policy in Emerging Market Economies,* BIS Papers Series, 35, pages 103-130, Bank for International Settlements.

Neely, C. J. (2005). An Analysis of Recent Studies of the Effect of Foreign Exchange Intervention. *Federal Reserve Bank of St. Louis Review,* 87(6), pp. 685-717.

Nogueira, R. P. Jr. (2007). Inflation Targeting and Exchange Rate Pass-through. *Economia Aplicada*, 11(2), pp. 189-208.

Nogueira, R. P. Jr. and M. Leon-Ledesma (2009). Fear of Floating in Brazil: Did Inflation Targeting Matter? *North American Journal of Economics and Finance,* 20(3), pp. 255-266.

Rincón, H. and J. Toro (2010). Are Capital Controls and Central Bank Intervention Effective? *Borradores de Economía*, 625, Banco de la República.

Sarno, L. and M. P. Taylor. (2001). Official Intervention in the Foreign Exchange Market: Is it Effective and, if so, How Does It Work? *Journal of Economic Literature,* 39(3), pp. 839-868.

Sims, C. A. (1986). Are Forecasting Models Usable for Policy Analysis? *Federal Reserve Bank of Minneapolis Quarterly Review*, 10(1), pp. 2-16.

Sims, C. A. (1992). Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy. *European Economic Review*, 36(5), 975-1000.

Sims, C. A. and T. Zha (2006). Does Monetary Policy Generate Recessions? *Macroeconomic Dynamics,* 10(2), pp. 231-272.

Stone, M. R., W. C. Walker and Y. Yasui (2009). From Lombard Street to Avenida Paulista: Foreign Exchange Liquidity Easing in Brazil in Response to the Global Shock of 2008–09. *IMF Working Papers*, WP/09/259, International Monetary Fund.

Tapia, M. and A. Tokman (2004). Effects of Foreign Exchange Intervention under Public Information: The Chilean Case. *Economía: Journal of the Latin American and Caribbean Economic Association,* 4(2), pp. 215-256.

Tobal, M. (2013). Currency Mismatch: New Database and Indicators for Latin America and the Caribbean. *CEMLA Research Papers*, *12*, available at http://www.cemla.org/PDF/investigacion/inv-2013-11-12.pdf.

Appendix Section

Table A1. Unit Root Test Statistics

Variable	Augmented Dickey-Fuller			Phillips-Perron		
	Brazil	Mexico	95% Critical value	Brazil	Mexico	95% Critical value
A. In Levels						
fei	-3.57**	-2.46**	-1.94	-4.91**	-3.01**	-1.94
i	-3.31*	-3.53**	-3.44	-2.78*	-3.01*	-3.44
m	-1.47*	-1.40*	-3.44	-5.25**	-2.06*	-3.44
cpi	-2.02*	-1.40*	-3.44	-1.52*	-4.17**	-3.44
ip	-2.78*	-2.41*	-3.44	-2.50*	-2.18*	-3.44
e	-2.26*	-3.38*	-3.44	-2.37*	-3.24*	-3.44
pc	-3.25*	-3.25*	-3.44	-2.68*	-2.68*	-3.44
B. In First Differences						
Δfei	----	----	----	----	----	----
Δi	-5.11**	-4.08**	-1.94	-4.18**	-10.81**	-1.94
Δm	-3.90**	-7.57**	-2.88	-21.72**	-19.90**	-2.88
Δcpi	-5.79**	-3.75**	-2.88	-5.83**	-9.72**	-2.88
Δip	-11.77**	-4.88**	-2.88	-11.73**	-15.03**	-2.88
Δe	-8.41**	-11.54**	-1.94	-8.40**	-11.54**	-1.94
Δpc	-4.37**	-4.37**	-1.94	-8.84**	-8.84**	-1.94

Sources: Banco Central do Brasil, Banco de México, and authors´ calculations.
Notes: The tests for variables in levels (panel A) include a constant and a liner trend, except for fei. The tests for Δm, Δcpi and Δip (in panel B) include only a constant, and for fei (in panel A), Δi, Δe, Δpc (in panel B) include neither a constant nor a liner trend. The lag lengths were chosen based on the AIC.
*The null hypothesis of a unit root cannot be rejected at 95% confidence level.
**The null hypothesis of a unit root is rejected at 95% percent confidence level.

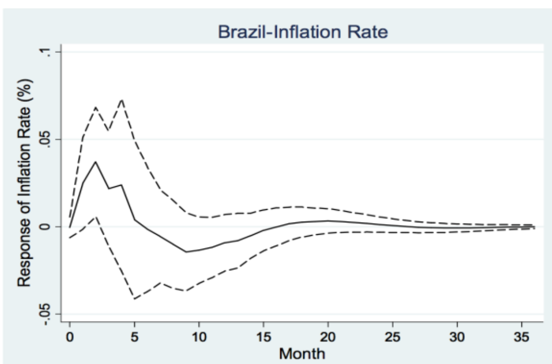
Table A2. Likelihood Ratio Test for Over-Identifying Restrictions (Baseline Model)

	Likelihood ratio statistic ($\chi^{(7)}$)	P-Value
VAR model for Brazil	11.34	0.125*
VAR model for Mexico	3.15	0.871*

Sources: Banco Central do Brasil, Banco de México, and authors´ calculations.
*Overidentifying restrictions are not rejected at 1, 5 and 10 percent levels.

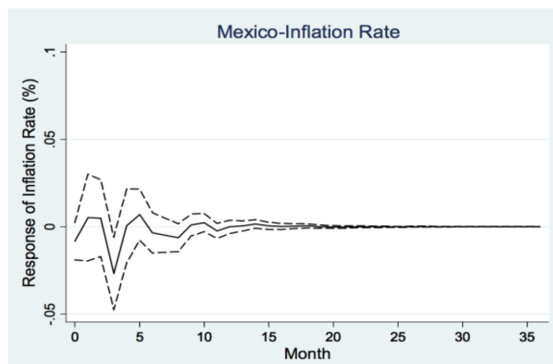
Response of Inflation Rate to Interest Rate Shocks (Baseline Model)

FIGURE A1



Sources: Banco Central do Brasil and authors´ calculations.
*The figure depicts the response to a positive interest rate shock at t=0.
**The dashed lines are 90% confidence bounds.
***We find the *price puzzle*: Inflation rate increases in response two months after the shock.
****Money market interest rate is used for the interest rate.

FIGURE A2



Sources: Banco de México and authors´ calculations.
*The figure depicts the response to a positive interest rate shock at t=0.
**The dashed lines are 90% confidence bounds.
***We do not find the *price puzzle:* Inflation rate falls in response three months after the shock.
****Money market interest rate is used for the interest rate.